FARMERS' BULLETIN 1226

TAKE-ALL OF WHEAT

AND ITS CONTROL

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

TAKE-ALL OF WHEAT was first discovered in this country in April, 1919, near Granite City, Madison County, Ill. It was found later in Sangamon and Mason Counties in the same State and in Laporte, Porter, and Tippecanoe Counties in Indiana.

Under conditions favorable to the disease, take-all may ruin an affected field of wheat. Usually, however, it occurs in irregular, scattered spots of different sizes. In most of the diseased fields the yields have been reduced less than 20 per cent.

Take-all is recognized in the field by dwarfed or stunted, "bunchy," dying plants in the spots mentioned.

All diseased plants tiller more than usual, which makes them look "bunchy." At first they are dull bluish in color, but later they turn brown and finally die. In the later stages of the disease, plants show more or less rotting of the roots and a brown rot of the stems underground.

If conditions are favorable for wheat, some of the diseased plants may partly recover and produce a small yield of grain, most of which is usually shrunken. Such plants mature later than the healthy ones.

Take-all may be controlled by sowing varieties of wheat known to be resistant to the disease.

Only a few varieties have been tested. Red Wave, Early May, and Turkey practically are immune from take-all, and Fultz and Fulcaster are very resistant. The so-called Salzer Prizetaker and the Red Cross, as grown in that part of Illinois in which this disease has been found, are so susceptible as to be worthless.

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C. August, 1921

TAKE-ALL OF WHEAT AND ITS CONTROL.[1]

HARRY B. HUMPHREY, *Pathologist in Charge*, AARON G. JOHNSON, *Pathologist*, and HAROLD H. MCKINNEY, *Assistant Pathologist, Cereal-Disease Investigations, Office of Cereal Investigations.*

CONTENTS.

DISCOVERY OF TAKE-ALL IN THE UNITED STATES.

The presence of take-all on winter wheat was discovered about the middle of April, 1919, through a report from the county agent of Madison County, Ill., that wheat near Granite City was being severely injured by some disease. Later this disease was found in other parts of Illinois and in Indiana.

Shortly after the discovery of this trouble the name "take-all" was applied to it tentatively on account of certain characteristics which it possessed in common with the Australian take-all of wheat. More extensive field and laboratory investigations indicate that it is different from the Australian disease, as it is generally understood to occur in Australia. However, until the cause of the type of disease occurring in Illinois and Indiana has been determined, the tentative use of the name "take-all" is continued.

ECONOMIC IMPORTANCE.

Under conditions favorable for its development, take-all may cause considerable damage. In the spring of 1919 some of the fields in Madison County, Ill., were so badly affected that they were plowed up and planted to other crops. In one case a 40 per cent actual reduction was caused in the total yield of grain in a 50-acre field in

[1] All the field experiments for the control of take-all have been conducted on fields in the "American bottoms" of the Mississippi River near Granite City, Ill., in cooperation with the Illinois Agricultural Experiment Station. Certain laboratory and greenhouse studies have been conducted in cooperation with the department of plant pathology at the Wisconsin Agricultural Experiment Station. In 1919 the field-laboratory studies were conducted in the laboratories of the Missouri Botanical Garden, St. Louis, Mo., through the kindness of Director George T. Moore and Dr. B. M. Duggar. In 1920, through the courtesy of Superintendent L. P. Frohardt, the field-laboratory studies were made in the laboratories of the Granite City, Ill., High School.

that county. In most cases observed, however, the actual reduction in yield has been less than 20 per cent.

Under conditions favorable for the wheat crop, the diseased plants recover to a considerable extent and produce some grain. Usually the disease so delays their growth that they do not mature until some time later than healthy plants and so contain only shrunken grain at harvest time. To reduce the losses of grain in badly infested fields it is necessary to postpone the harvest date until the bulk of the crop is ripe. Frequently it is more economical to suffer a small loss due to the shattering of the overripe, healthy grain than to lose the late-maturing grain in the infested patches. In cases where there

FIG. 1.—Portion of a spot in a wheat field infested with take-all.

is a large diseased area in a field it is best to harvest it separately later, thus reducing the losses to the minimum.

GEOGRAPHIC DISTRIBUTION.

So far as known this particular disease occurs only in the States of Illinois and Indiana. There is a possibility that it may be present in Colorado, but this has not been determined with certainty.

Similar troubles have appeared in Virginia, Kansas, and Washington, but investigations indicate that these have had a different cause. One small outbreak of the true Australian take-all apparently has occurred in New York, another in Arkansas, and a third in Oregon.

CROPS AFFECTED.

Investigations conducted thus far have not shown positively that any other crop but wheat is susceptible to the disease. There are some indications that rye may be very slightly susceptible.

SYMPTOMS.

SYMPTOMS IN THE SPRING.

The conspicuous symptoms of the disease first become evident in the spring after growth of the healthy plants is well started. Distinct patches of badly dwarfed plants show up here and there in some fields without regard to the type or condition of the soil (fig. 1). Some of these patches may be so small as to include only a comparatively few diseased plants; sometimes, in fact, the diseased plants may occur one in a place, here and there, intermixed with apparently healthy plants. In such cases these diseased plants are difficult to find, and hence are commonly overlooked. Definite spots containing diseased plants usually can be recognized. The edge of such a spot generally is more sharply defined than the margins of spots caused by unfavorable soil conditions, especially poor drainage. In such

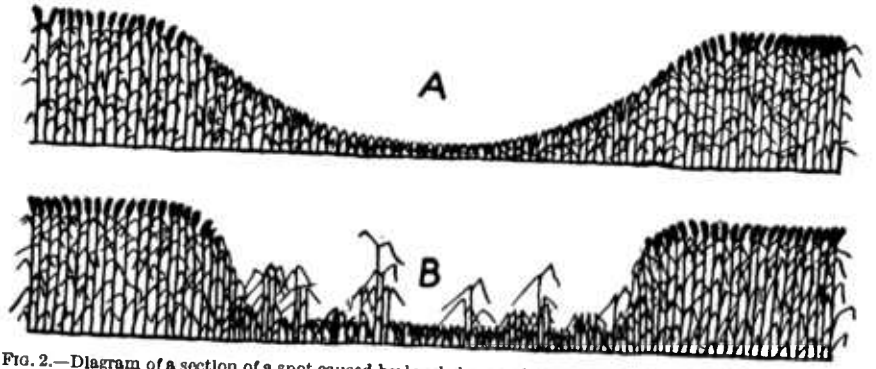

FIG. 2.—Diagram of a section of a spot caused by local abnormal soil conditions (*A*) and a spot caused by take-all (*B*).

spots most of the plants are diseased, and therefore stunted right up to the edge of the spot (fig. 2, *B*). In spots caused by local unfavorable soil conditions all the plants usually decrease in height rather gradually from the edge toward the center (fig. 2, *A*).

In fields more severely infested, the patches may be very large and contain a high percentage of diseased plants, or even cover large portions of the infested fields.

Wherever found, the diseased plants show certain distinct characteristics, particularly (1) dwarfing, and a little later (2) abnormal dark-green coloration of the fall leaves, (3) dying of outer leaves and fall tillers and basal browning, (4) excessive development of spring tillers, or (5) some plants may be killed entirely.

Early in the spring, if healthy and diseased plants growing side by side are pulled up, it will be noted that the disease is fairly well limited to individual plants which at that time show marked dwarfing but no basal browning of the living tissues. A little later the dis-

eased plants show a browning, and still later a rotting of the basal portions, that is, those parts just below the surface of the ground. The roots may not show any particular evidence of disease or they

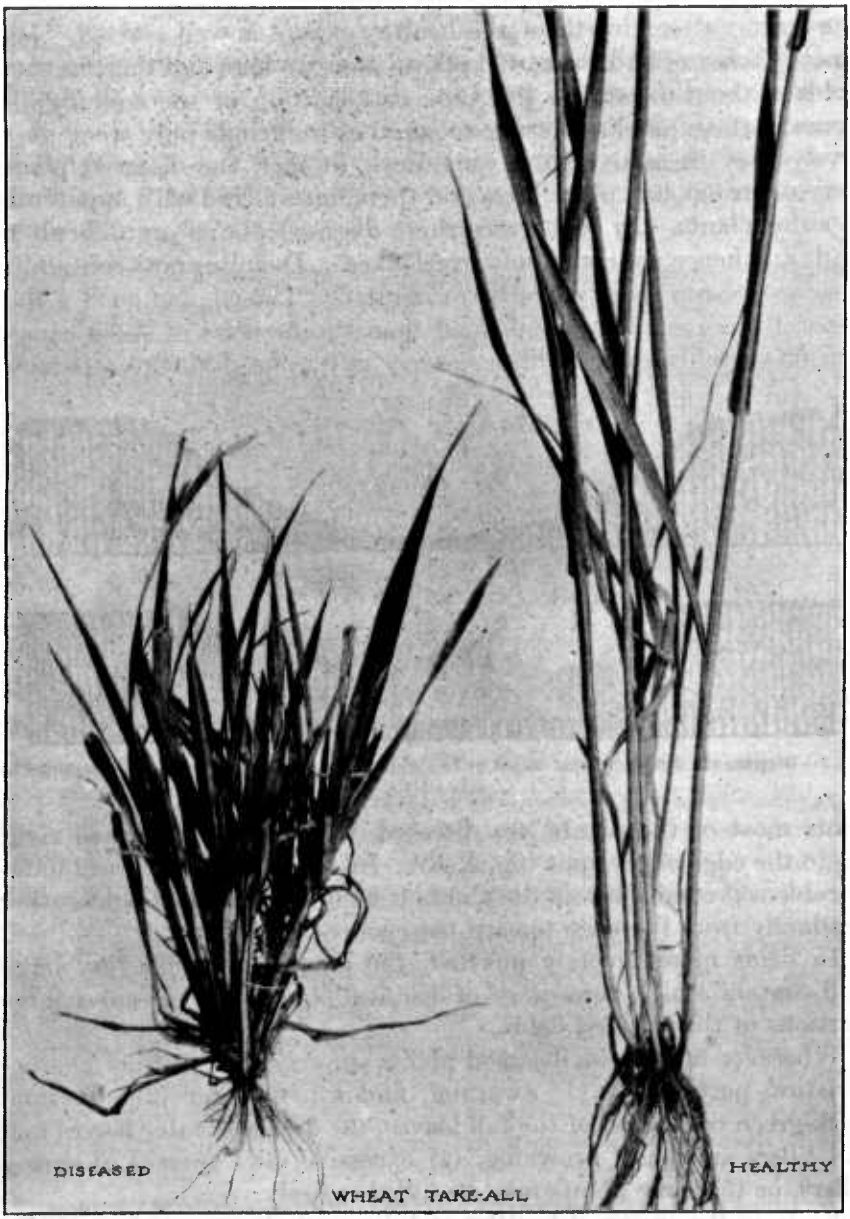

FIG. 3.—Diseased and healthy wheat plants.

may show some discoloration when the basal browning occurs. The diseased plants may be immediately adjacent to and intermixed with healthy plants. Along with the development of the basal

browning and rotting, spring tillers become evident in excessive numbers, giving the diseased plants a "bunchy" appearance (fig. 3). Under certain soil conditions, especially when the soil is dry, some of the diseased plants die in the spring, while still in the dwarfed stage.

SYMPTOMS LATER IN THE SEASON.

When the healthy wheat plants are beginning to head, or the heads are in the "boot," the diseased plants usually show partial recovery (fig. 4) and send up one or more short, weak stems. In some cases, where soil conditions are very favorable, rather complete recovery may occur, so that the infested areas may be difficult to locate by the time the crop is mature.

When healthy plants are ripening, the diseased plants are still green. On account of this, the infested areas show up conspicuously as green spots in the ripening healthy grain. Frequently, especially in wet seasons, the development of weeds in the infested areas adds to the general green effect brought about by the green condition of the diseased plants.

When the diseased plants recover enough to develop heads, these are short and only imperfectly filled or not filled at all. This is in striking contrast with the large well-filled heads of healthy plants (fig. 5) at harvest time.

RECURRENCE.

In 1919, when the disease was first observed, it was thought by some that the trouble was caused by the exceptionally mild winter of 1918 and 1919, and considerable doubt was expressed whether the disease would reappear in a normal season. At the present time, however, there can be little doubt on this point, as the disease recurred in the spring of 1920, following a winter which was much more severe than the preceding one. From present knowledge, there is every reason to believe that the disease will recur every year when susceptible varieties of wheat are sown on infested land.

CAUSE.

The cause of the take-all has not yet been determined. A fungus (*Helminthosporium* sp.) has been found rather closely associated with the advanced stages of the trouble. The Helminthosporium disease of wheat is present in many sections of the United States, and it is possible that the take-all as it appears in Illinois and Indiana is only an unusually severe form of the common type of that disease. The exact relation of Helminthosporium to the disease found in the two States mentioned is as yet undetermined.

CONTROL.

Various control measures for the disease have been tested, and important progress has been made. It is known that the soil

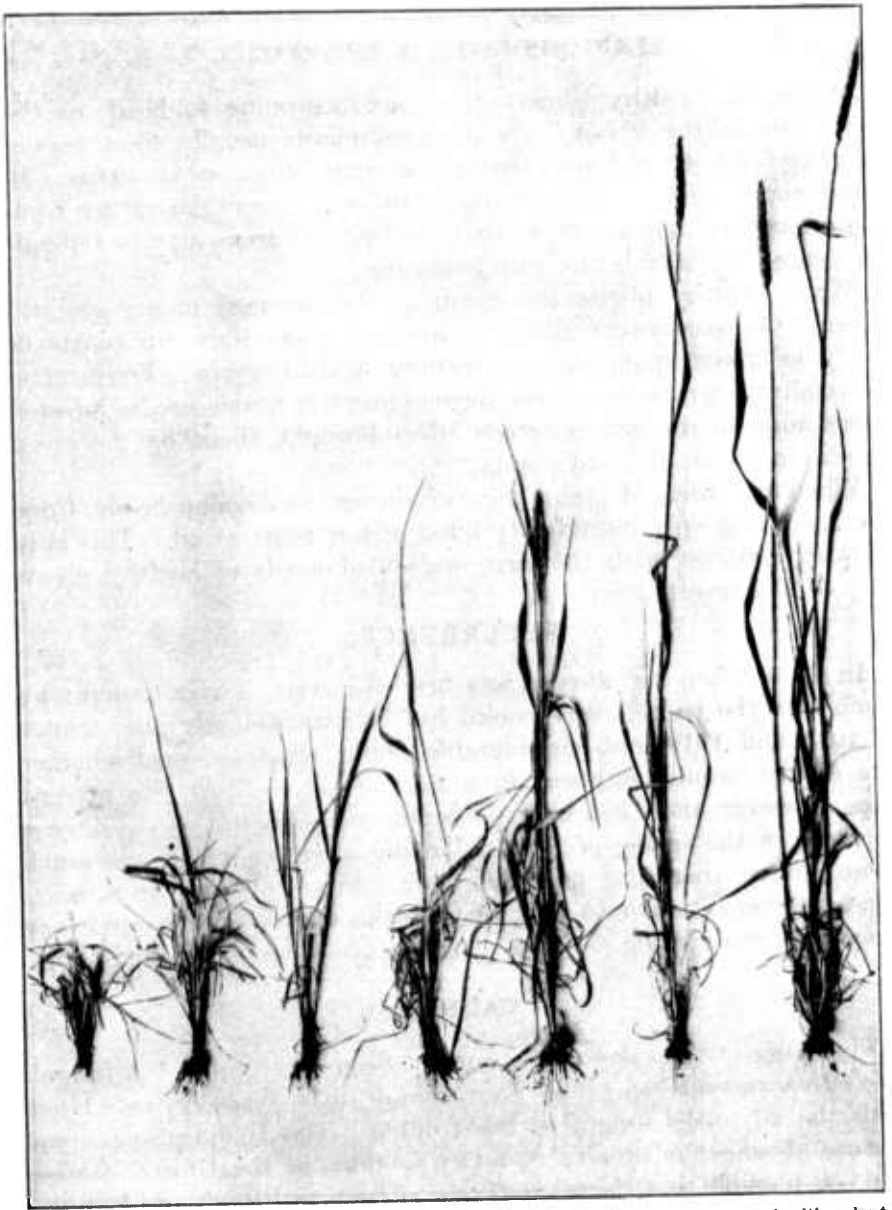

FIG. 4.—Wheat plants at the flowering stage, showing all stages of take-all injury. A healthy plant on the right.

carries the causal factor, whatever it is. Attempts to control the disease on infested land by seed treatments, therefore, are useless. So far, there is no indication that cropping methods, summer fallow,

burning the diseased stubble, or the application to the infested soil of ground limestone, fertilizers, or chemicals, such as iron sulphate, will control the disease perceptibly.

RESISTANT VARIETIES.

Preliminary experiments conducted with ten of the leading varieties of winter wheat adapted to Illinois conditions indicate that the disease can be controlled by the use of resistant varieties.

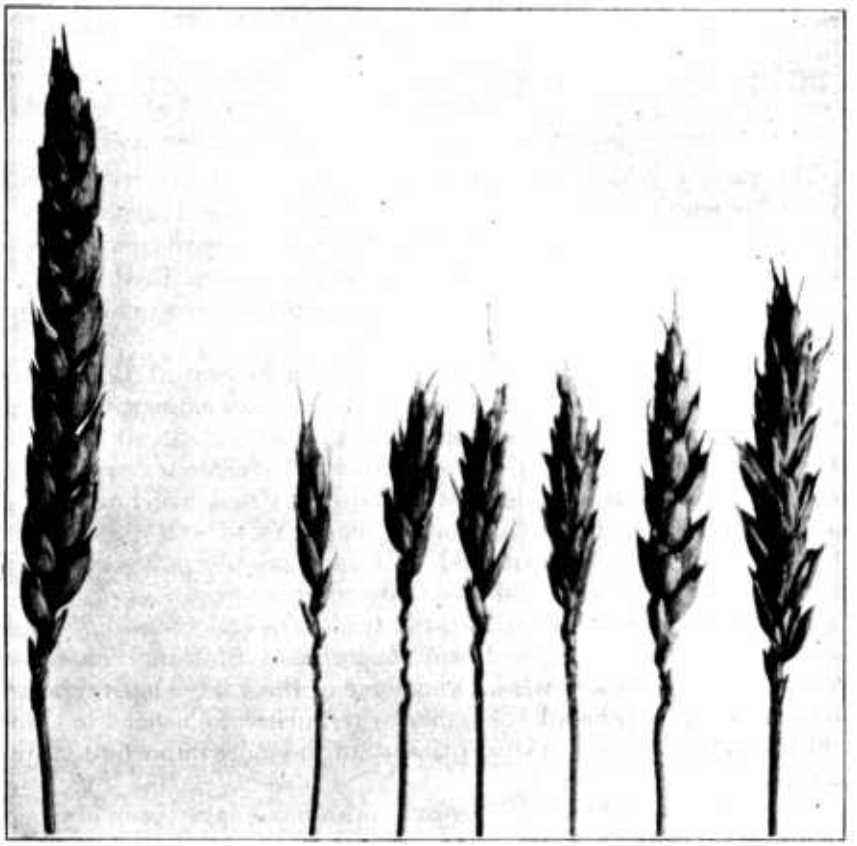

FIG. 5.—Head from a healthy wheat plant (left). Heads from diseased plants partially recovered (right).

The varieties tested were sown in adjacent parallel strips, one drill width (54 inches) wide and 50 rods long, on a uniformly infested and practically level field located near Granite City, Ill.

The results of the trials are briefly summarized in Table I. The varieties are listed in the same order in which they were sown in the plats.

It is evident from the results of the varietal experiments that Salzer Prizetaker, Red Cross, and Illini Chief are very susceptible to the disease and that the Red Wave, Early May, and Turkey varieties are apparently immune.

TABLE I.—*Resistance and susceptibility to take-all of certain varieties of wheat, as shown by tests conducted near Granite City, Ill., in 1920.*

Variety of wheat.		Take-all in plats.	Yield per acre.	Weight per bushel.
Local name.	True name.			
		Per cent.	*Bushels.*	*Pounds.*
Salzer Prizetaker	Harvest Queen	90	8.87	54.75
Red Wave	Red Wave	0	28.33	56.75
Illini Chief	Illini Chief	25 to 30	24.08	58.00
Harvest King	Harvest King	Trace.	28.83	56.50
May	Early May	0	25.61	58.50
Red Cross	Harvest Queen	78	13.51	53.00
Fultz	Fultz	2	26.20	59.50
Winter Fife	Jones Fife	2 plants.	32.87	58.50
Turkey Red	Turkey	0	21.50	60.00
Fulcaster	Fulcaster	2	25.80	60.75

The variety grown in central Illinois under the name Salzer Prizetaker has white chaff and red kernels, and it is this variety which is susceptible. The original Salzer Prizetaker was a variety with brown chaff and white kernels, but it is no longer grown in this part of Illinois and has not been tested, so its susceptibility to take-all is not known.

The susceptible Red Cross variety grown in central Illinois also has a white chaff and red kernels. It and the susceptible Salzer Prizetaker variety are identical and also are identical with the Harvest Queen. Another variety grown to some extent in the eastern United States under the name Red Cross has brown chaff and red kernels. This also has not been tested and therefore its susceptibility is not known. All of these varieties going under the names Salzer Prizetaker and Red Cross are beardless.

The Turkey variety used in these trials was the "Station" strain used at the Illinois Agricultural Experiment Station. There are many strains of Turkey wheat, and some of them have been reported to be affected by take-all. Further experiments are needed to throw additional light upon the susceptibility of the more important strains of this variety.

The Early May and Red Wave varieties have never been observed to be susceptible to the disease. These varieties often have been found sown in parts of fields of Salzer Prizetaker or Red Cross, but were always free from the disease, while the latter varieties showed severe injury.

From the experimental results it is evident that the most satisfactory means of controlling the disease lies in the discarding of the susceptible varieties in localities where the disease occurs and using only the resistant sorts. It is possible that the slight percentage of the disease apparently present in some of the varieties in 1920 was due to slight mixtures of susceptible varieties, and when perfectly pure seed is available still other varieties may be found to be resistant.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO WHEAT.

AVAILABLE FOR FREE DISTRIBUTION.

Culture of Winter Wheat in the Eastern United States. By Clydo E. Leighty. Maps 2, pp. 12. (Farmers' Bulletin 596.)

Winter Wheat Varieties for the Eastern United States. By Clyde E. Leighty. Figs. 6, pp. 14. (Farmers' Bulletin 616.)

Growing Hard Spring Wheat. By Carleton R. Ball and J. Allen Clark. Figs. 4, pp. 16. (Farmers' Bulletin 678.)

Marquis Wheat. By Carleton R. Ball and J. Allen Clark. Pp. 7. (Farmers' Bulletin 732.)

Methods of Controlling or Eradicating Wild Oats in Hard Spring Wheat Area. By H. R. Cates. Figs. 9, pp. 16. (Farmers' Bulletin 833.)

Wheat Growing in the Southeastern States. By Clyde E. Leighty. Pp. 14. (Farmers' Bulletin 885.)

Growing Winter Wheat on the Great Plains. By E. C. Chilcott and John S. Colo. Pp. 12. (Farmers' Bulletin 895.)

Cereal Smuts and Disinfection of Seed Grain. By Harry B. Humphrey and Alden A. Potter. Figs. 16, pp. 28. (Farmers' Bulletin 939.)

Wheat Jointworm and its Control. By W. J. Phillips. Figs. 17, pp. 14. (Farmers' Bulletin 1006.)

Eelworm Disease of Wheat and its Control. By Luther P. Byars. Figs. 26, pp. 18. (Farmers' Bulletin 1041.)

Take-All and Flag-Smut, Two Wheat Diseases New to the United States. By Harry B. Humphrey and Aaron G. Johnson. Figs. 3, pp. 8. (Farmers' Bulletin 1063.)

Dockerage Under the Federal Wheat Grades. By Ralph Brown. Figs. 10, pp. 26. (Farmers' Bulletin 1118.)

Varieties of Winter Wheat Adapted to the Eastern United States. By Clydo E. Leighty. Figs. 5, pp. 18. (Farmers' Bulletin 1168.)

Flag Smut of Wheat and Its Control. By W. H. Tisdale and Marion H. Griffiths. Figs. 2, pp. 6. (Farmers' Bulletin 1213.)

Experiments with Marquis Wheat. By Carleton R. Ball and J. Allen Clark. Figs. 10, pp. 40. (Department Bulletin 400.)

The Drying for Milling Purposes of Damp and Harlicky Wheat. By J. H. Cox. Figs. 3, pp. 11. (Department Bulletin 455.)

A Comparison of Soveral Classes of American Wheats and Consideration of Somo Factors Influencing Quality. By L. M. Thomas. Figs. 21, pp. 28. (Department Bulletin 557.)

Geography of Wheat Prices. By L. B. Zapoleon. Fig. 1, maps 7. Pp. 46. (Department Bulletin 594.)

Nematode Galls as a Factor in the Marketing and Milling Wheat. By D. A. Coleman and S. A. Regan. Figs. 7, pp. 16. (Department Bulletin 734.)

Moisture in Wheat and Mill Products. By J. H. Shollenberger. Figs. 2, pp. 12. (Department Bulletin 788.)

Varietal Experiments with Spring Wheat on the Northern Great Plains. By J. Allen Clark, John H. Martin, and Ralph W. Smith. Figs 2, pls. 3, pp. 48. (Department Bulletin 878.)

Occurrence of Wheat Downy Mildew in the United States. By William H. Weston, jr. Pp. 6. (Department Circular 186.)

World's Supply of Wheat 1917. Pp. 22. (Separate 752 from Yearbook 1917.)

Cereal Diseases and National Food Supply. Pp. 16. (Separate 755 from Yearbook 1917.)

Farm Practices in Growing Wheat. Pp. 27. (Separate 804 from Yearbook 1919.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Durum Wheat. By Cecil Salmon and J. Allen Clark. Figs. 4, pp. 16. (Farmers' Bulletin 534.) Price, 5 cents.

Varieties of Hard Spring Wheat. By Carleton R. Ball and J. Allen Clark. Figs. 7, pp. 20. (Farmers' Bulletin 680.) Price, 5 cents.

Alaska and Stoner or Miracle Wheats. Two Varieties Much Misrepresented. By Carleton R. Ball and Clyde E. Leighty. Figs. 6, pp. 28. (Department Bulletin 357.) Price, 5 cents.

Improvement of Ghirka Spring Wheat in Yield and Quality. By J. Allen Clark. Figs. 17, pp. 20. (Department Bulletin 450.) Price, 5 cents.

The Origin, Characteristics, and Quality of Humpback Wheat. By Levi M. Thomas. Fig. 1, pl. 1, pp. 4. (Department Bulletin 478.) Price, 5 cents.

Wheat, Yields per Acre and Price by States, 50 Years, 1866–1915. Pp. 16. (Department Bulletin 514.) Price, 5 cents.

Characteristics and Quality of Montana-Grown Wheat. By Levi M. Thomas. Figs. 17, pls. 2, pp. 34. (Department Bulletin 522.) Price, 10 cents.

The Nematode Disease of Wheat Caused by *Tylenchus tritici*. By L. P. Byars. Figs. 6, pls. 6, pp. 40. (Department Bulletin 842.) Price, 20 cents.

Australian Wheat Varieties in the Pacific Coast Area. By J. Allen Clark, David E. Stephens, and Victor H. Florell. Pls. 3, pp. 25. (Department Bulletin 877.) Price, 10 cents.

Cost of Producing Wheat on 481 Farms of North and South Dakota, Minnesota, Kansas, Nebraska, and Missouri for the Crop Year 1919. By M. R. Cooper and R. S. Washburn. Figs. 9, pls. 2, pp. 59. (Department Bulletin 943.) Price, 15 cents.

Environment Influence on Physical and Chemical Characteristics of Wheat. (In Journal of Agricultural Research. Jan. 1914, pp. 275–291.) Price, 25 cents.

Injury to Seed Wheat Resulting from Drying After Disinfection with Formaldehydo. (In Journal of Agricultural Research. Nov. 1, 1920, pp. 209–244.) Price, 10 cents.

Yellow-berry in Hard Winter Wheat. (In Journal of Agricultural Research. Nov. 1, 1919, pp. 155–169.) Price, 20 cents.

Rust in Seed Wheat and Its Relation to Seedling Infection. (In Journal of Agricultural Research. June 15, 1920, pp. 257–277.) Price, 25 cents.

○